Correlation analysis of offshore wind and wave power potential at Indian exclusive economic zone during 2014–23 using deep learning model

S. Vasavi*, M. Sobhana and Bittu Singha

Velagapudi Ramakrishna Siddhartha Engineering College, Vijayawada 520 007, India

Climate change is increasingly influencing energy resources across the globe, and its effects on renewable energy sources like offshore wind and wave power are becoming crucial topics of study. India, with its extensive coastline and vast exclusive economic zone (EEZ), has significant potential for harnessing these ocean-based renewable energies. By analysing the localised nature of offshore winds and their sensitivity to climate variations, we can improve predictions of future wind power output. Therefore, to sustain wind energy development within India's EEZ, it's essential to evaluate the region's wave energy potential and its vulnerability to climate change. This paper investigates the potential for offshore wind energy within the Indian EEZ and assesses its vulnerability to climate change. Spatial and temporal wave data such as wave period and wave height are collected from Copernicus Marine Data Store to generate the wave power layer and validate the proposed U-Net model. For improvement of data quality, assimilation techniques such as the Kalman filter and Bilateral filter are used. For finding the wave power density hotspot region, the semantic segmentation is performed using an enhanced U-Net model. The model archives an impressive IoU score of 82.66%, conforming its accuracy to identify the wave power density hotspots. To analyse the impact of climate change on wave power potentials, the Pearson correlation technique is used to correlate between ocean surface salinity and ocean surface temperature. The *r* value of correlation between ocean surface temperature and ocean surface salinity ranges from –0.59 to –0.0 and indicates a weak, moderate inverse relationship, the positive range varies from 0.01 to 0.62, suggest that a weak to strong positive correlation, where both temperature and salinity tend to increase together. In the case of temperature and wave power density, there is a negative correlation from June to October, influenced by seasonal temperature variation due to rainfall and it effects to correlate with wave power density.

Keywords: Exclusive economic zone, Kalman filter, U-net model, wave energy potential, wave power density hotspots.

*For correspondence. (e-mail: vasavi_movva@vrsiddhartha.ac.in)

THE Indian exclusive economic zone (EEZ), covering about two million square kilometres, holds significant potential for offshore energy resources, particularly wave energy. However, climate change impacts oceanic parameters, which are likely to affect the wave power potential in many ways. Changes in ocean surface salinity, ocean surface temperature, wave height and wave period directly influence the offshore wind and energy project. India, with its extensive coastline and vast EEZ, has significant potential for harnessing these ocean-based renewable energies. Despite the global offshore wind market reaching nearly 75 GW in capacity, India has yet to establish offshore wind projects. However, India aims to achieve 500 GW of renewable energy capacity by 2030, including around 100 GW from wind energy, with 30 GW projected to come from offshore sources[1].

The global climate change has become a major factor affecting energy production and consumption continues rise gradually in the 20th century[2]. As a replacement for fossil fuels, ocean wave energy presently provides a solution to the growing demand for sustainable energy. Due to advancement in technology, which allows more accurate ocean wave energy potential, providing a reliable pathway for future energy solutions. India's share of global energy consumption was expected to increase from 5% in 2016 to 11% in 2024 (ref. 3). This rapid increase in demand emphasizes India's expanding role in the global landscape as industrialization, urbanization and population growth. While solar become has widely adopted, India's extensive coastline makers wave energy an attractive and compatible option for future energy development. A major issue is the huge global dependence on fuels to meet human needs, resulting in excessive CO_2 emissions that tend to cause global warming and climate change[4,5]. In India, studies on statistical analyses of wave energy trends from 1998 to 2009 in the Indian Ocean[6] and wave parameters belonging to six zones within the Bay of Bengal, Arabian Sea from 1993 to 2010 (ref. 7) reveal an increase in wind speed in the southern Indian Ocean during monsoon and post-monsoon seasons. The research on wave power potential towards the coast of Chennai[8,9] shows the influence of wave climates in the Indian EEZ, covering tropical basins, Arabian Sea and the Bay of Bengal.